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FLUID RESISTANCE TESTING OF ELECTRICAL WIRE USED IN AIRCRAFT AN--ETC(U)
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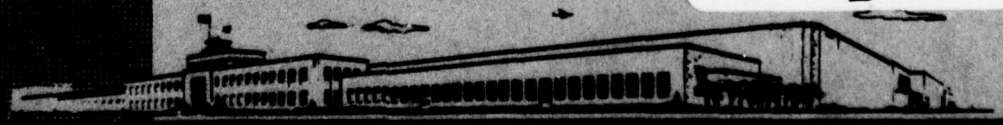
FLUID RESISTANCE TESTING OF ELECTRICAL WIRE USED IN AIRCRAFT AND MISSILES

PART III



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PREFACE

This report describes an investigation into the ability of the insulation on aircraft electrical wire to withstand exposure to cleaners and paint removers which are used on aircraft surfaces. It is a continuation of work reported in NAFI TR-2199[1] and TR-2145[2].

This work was performed for NAVAIR under Work Request No. 68E95.

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PREPARED BY: W D Watkins
W. D. WATKINS

APPROVED BY: F H Gahimer
F. H. GAHIMER, Head
Organic Materials Branch

B C Vaughn
B. C. VAUGHN, Director, Materials
Laboratory and Consultants Division

ABSTRACT

Several types of insulated electrical wire purchased to MIL-W-22759, MIL-W-81044 and MIL-W-81381, along with a new fluoropolymer insulated wire, were immersed in solvents purchased to MIL-C-43616 and TT-R-248. The ability of the insulation to withstand degradation by the solvents was determined by subjecting the conditioned wire to a dielectric withstand voltage test. This testing differs from previous testing[1,2] in that the fluids were maintained at 75°C during immersion of the wire specimens.

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I. CONCLUSIONS

1. The wires tested herein are ranked in the order of decreasing resistance to solvent damage as follows:

Wire Code	Military Part No.	Insulation Type
1*	M22759/18-20-9	Tefzel
23*	55A0811-20-9	Irradiated Modified Tefzel
11	M81381/11-20-N	Double Wrap Kapton
3	M81044/16-20-9	Double Extruded Poly-X
12	M81381/7-20-2	Single Wrap Kapton
4	M81044/18-20-9	Single Extruded Poly-X

* No difference in rank.

2. Both Tefzel (M22759/18-20-9) and irradiated modified Tefzel (55A0811-20-9) insulated wires are superior in solvent resistance to all other types tested. Kapton insulated wire has better solvent resistance than Poly-X insulated wire.

3. The new MIL-C-43616, Amend. 2, cleaning fluid with a pH of 9.2 will cause far less solvent attack on wire insulation than previous types with a pH $\geq$ 11.

4. Elevated temperatures increase the activity of the MIL-C-43616 fluids used. Of the wire types susceptible to damage, the damage occurs faster at 75^{o}C than at room temperature.

II. RECOMMENDATIONS

1. Of the wires tested herein, serious consideration for use should be given to both M22759/18-20-9 (Tefzel) and 55A0811-20-9 (irradiated modified Tefzel) wire.

III. INTRODUCTION

Previous testing[1] had established the time-to-failure of wires No. 3, 4, 11 and 12 when immersed in fluids A and N. It was concluded that Kapton insulated wire performed better than Poly-X insulated wire in similiar wall thicknesses.

The temperatures within the aircraft can be as high as 75°C (higher in engine compartments). If a wiring harness is inadvertently contaminated with cleaning solutions or paint remover, it may be degraded faster than expected due to the elevated temperature.

It is the purpose of this investigation to:

1. Compare the solvent resistance of Poly-X and Kapton insulated wire by immersion in fluids at 75°C.

2. Compare the solvent resistance of Tefzel and Irradiated Modified Tefzel insulated wire by immersion in fluids at 75°C.

3. Compare the relative degree of damage caused by MIL-C-43616 cleaning solutions at room temperature and at 75°C.

IV. MATERIALS

A. Fluids

Three fluids were chosen for use in this investigation. Fluids A and N are MIL-C-43616 cleaning compounds and Fluid G is a TT-R-248 paint remover. All three were previously used[1,2] and are identified in the same manner as in the previous reports. A complete description of the fluids used is given in Appendix C.

B. Wires

Six different insulated wires were used. Wires with code numbers 1, 3, 4, 11 and 12 are the same as those used in TR-2145[2]. One new wire was added. It is identified as wire code number 23. The wires are listed by code number and military specification in Tables 1 through 3. A complete description appears in Appendix C.

V. PROCEDURE

The fluids were used in the concentrated "straight from the can" form. This is the usual procedure for using the paint removers. While the cleaning solutions are sometimes used in the concentrated condition, they are usually diluted for use. Specifications requiring pH to be measured use a 1:4 dilution with water. For this investigation, pH of the solutions was measured in concentrated 1:4 dilution and 1.9 dilution form.

Three specimens from each of the six wire samples were tested in each of the three fluids for immersion times of 1 through 7 consecutive days, 2 weeks, 3 weeks and 4 weeks. The fluids were maintained at 75°C during immersion.

Testing in TT-R-248 (Fluid G) was discontinued after two days due to the condition of the fluid. A hard gum-like material formed which was difficult to remove from the wire specimens without damage to the insulation. However, test results to that point were similar to those obtained with MIL-C-43616 (pH = 13.3), Fluid A.

The wire samples were cut to 2 foot lengths with the ends stripped on an automatic Eubanks wire cutting machine. The specimens were formed from the 2 foot lengths by making a single turn loop with the ends of the wire run through the loop twice to secure the loop.

The loop was formed to a 1 inch diameter on a rod of that size and the stripped conductor ends twisted together. Identification tags were placed upon each specimen indicating the wire and fluid code and the time of immersion.

All specimens (#1, #2, and #3) were immersed in the test fluid in the "as looped" condition.

After immersion, specimen #1 was rinsed in tap water and allowed to dry one hour at room ambient conditions. It was then immersed for 1 hour in tap water containing an anionic wetting agent. While still in the tap water the insulation was subjected to a 1 minute dielectric withstand test of 2500 volts rms.

After immersion, specimen #2 was rinsed in tap water, uncoiled and allowed to dry for 1 hour at room ambient conditions. It was then subjected to the "double reverse wrap" on a 0.125" diameter mandrel as specified in the solvent resistance test procedure of the wire specifications. Following this, the specimen was formed into a loose coil and immersed in tap water for 1 hour before being subjected to a 1 minute dielectric withstand test of 2500 volts rms.

After immersion, specimen #3 was rinsed in tap water, uncoiled, and allowed to dry for 24 hours at room ambient conditions. Next, it was subjected to the "double reverse wrap" on a 0.125" mandrel, formed into loose coil, and immersed in tap water for 1 hours. The insulation was then subjected to a 1 minute dielectric withstand test of 2500 volts rms.

VI. RESULTS AND DISCUSSION

A. pH TESTING

The pH of the fluids was as follows:

	Fluid Code	Specification	pH		
			Conc.	1:4	1:9
As Received	A	MIL-C-43616	13.3	11.9	11.6
	G	TT-R-248	11.6	11.2	11.0
	N (New)	MIL-C-43616B,Amend#2	9.2	9.2	9.1
After 28 days at 75°C (tested at room temp.)	A	MIL-C-43616	10.4	10.1	10.2
	G	TT-R-248	not tested		
	N	MIL-C-43616B,Amend#2	8.7	8.8	8.9

Aging for 28 days at 75°C significantly lowers the pH of Fluid A and only slightly lowers the pH of Fluid N.

B. Fluid Immersion

The dielectric withstand failures are shown in Tables 1 through 3.

There were no failures of either Tefzel (M22759/18-20-9) insulated wire or Irradiated Modified Tefzel (55A0811-20-9) insulated wire in any of the fluids tested. Both of these are promising for such applications.

Table 4 contains the results obtained in previous testing[1,2] as well as those obtained in current testing. The wires are listed in order of decreasing resistance to solvent damage.

It is concluded that double extruded Poly-X is superior to single extruded Poly-X. Double wrap Kapton is superior to single

wrap Kapton. Single wrap Kapton is slightly better than single extruded Poly-X. Double wrap Kapton is not different from double extruded Poly-X.

The results also indicate that if cleaning were restricted to the use of fluids no more active than the new MIL-C-43616, Amend. 2 (pH = 9.2) fluid, only the single extruded Poly-X insulation would likely be attacked.

REFERENCES

[1] "Fluid Resistance Testing of Electrical Wire Used in Aircraft and Missiles, Part II", NAFI TR-2199, 11 Aug 1977

[2] "Fluid Resistance Testing of Electrical Wire Used in Aircraft and Missiles", NAFI TR-2145, 11 Aug 1976

APPENDIX A

TABLE 1.

DIELECTRIC WITHSTAND FAILURES, FLUID A

WIRE CODE	MILITARY PART NUMBER	DAYS OF TEST (75°C)										TOTAL NO.OF FAIL-URES	NO.OF SPECI-MENS TESTED
		1	2	3	4	5	6	7		21	28		
1	M22759/18-20-9											0	30
3	M81044/16-20-9	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	30	30
4	M81044/18-20-9	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	30	30
11	M81381/11-20-N	3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	28	30
12	M81382/7-20-2	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	30	30
23	55A0811-20-9											0	30

Grand Total = 118 180

Note: No entry: All three specimens passed.
1: Specimen No. 1 failed.
2: Specimen No. 2 failed.
3: Specimen No. 3 failed.

TABLE 2.

DIELECTRIC WITHSTAND FAILURES, FLUID N

WIRE CODE	MILITARY PART NUMBER	DAYS OF TEST (75°C)										TOTAL NO.OF FAIL-URES	NO.OF SPECI-MENS TESTED
		1	2	3	4	5	6	7	14	21	28		
1	M22759/18-20-9											0	30
3	M81044/16-20-9											0	30
4	M81044/18-20-9				2		3	1,2	2,3	2,3	2,3	10	30
11	M81381/11-20-N											0	30
12	M81381/7-20-2										1,2,3	3	30
23	55A0811-20-9											0	30
										Grand Total	=	13	180

Note: No entry: All three specimens passed.
1: Specimen No. 1 failed.
2: Specimen No. 2 failed.
3: Specimen No. 3 failed.

TABLE 3.

DIELECTRIC WITHSTAND FAILURES, FLUID G

WIRE CODE	MILITARY PART NUMBER	DAYS OF TEST (75°C) 1	2	
1	M22759/18-20-9			TEST TERMINATED DUE TO CONDITION OF TEST FLUID
3	M81044/16-20-9	2		
4	M81044/18-20-9	2,3	2,3	
11	M81381/11-20-N			
12	M81381/7-20-2		1,2,3	
23	55A0811-20-9			

Note: No entry: All three specimens passed.
1: Specimen No. 1 failed.
2: Specimen No. 2 failed.
3: Specimen No. 3 failed.

TABLE 4.

SUMMARY OF RESULTS TO DATE *

WIRE CODE	INSULATION	SPECIFICATION	DAYS TO FIRST FAILURE IN FLUID					
			MIL-C-43616				TT-R-248	
			A(pH = 13.3)		N(pH = 9.2)		G(pH = 11.6)	
			RT	75°C	RT	75°C	RT	75°C**
1	Tefzel	M22759/18-20-9	> 28	> 28	> 28	> 28	> 28	> 2
23	Irradiated Modified Tefzel	55A0811-20-9	***	> 28	***	> 28	***	> 2
11	Kapton, Double Wrap	M81381/11-20-N	7	1	> 28	> 28	4	> 2
12	Kapton, Single Wrap	M81381/7-20-2	7	1	> 28	28	7	2
3	Poly-X, Double Extruded	M81044/16-20-9	3	1	> 28	> 28	14	1
4	Poly-X, Single Extruded	M81044/18-20-9	1	1	28	4	1	1

* Also contains data from TR-2199[1] and TR-2145[2].

** Test terminated after two days.

*** Not tested at RT.

APPENDIX C

APPENDIX C.

DESCRIPTION OF FLUIDS AND WIRES USED

A. FLUIDS

The fluids chosed for this investigation are as follows:

1. MIL-C-43616, "Cleaning Compound, Aircraft Surface". This cleaning compound used by the Navy is water rinsable and required to be 90% biodegradable. The flash point is 142°F (min) and the pH of a 1:4 water dilution must fall between 8.0 and 12.0. The specification does not limit the composition of the cleaner; however, it does list a comparison formula with which to compare the cleaning effectiveness, and a recent amendment (2) limits the pH to 10 max. Two fluids were used: Fluid A (previously tested) with a pH of 13.3, and a new fluid (N) with a pH of 9.2 (both pH's measured in the concentrated form).

2. TT-R-248, "Remover, Paint and Lacquer, Solvent Type". This is a non-flammable, water rinsable solvent type paint and lacquer remover. It must not contain phenol, cresol, creosote oil, cresylic acid, benzene, carbon tetrachloride, perchloroethylene, trichloroethylene, or dichlorethylene. It may contain other chlorinated hydrocarbons if shown to have no deleterious effect on the aircraft. There is no requirement for pH. The specification does not contain a comparison formula. Fluid G (previously tested), containing methylene chloride and having a pH in concentrated form of 11.6, was used.

B. WIRES

The wires chosen for this investigation are as follows:

1. MIL-W-22759/18-20-9. This is an extruded ETFE fluorocarbon insulation on silver coated 19 strand copper conductor (AWG 20) and is white (-9). This wire was tested in TR-2145[2] and identified by Wire Code #1.

2. MIL-W-81044/16-20-9. This is a double extruded alkane-imide with an imide topcoat. It has a tin coated 19 strand copper conductor (AWG 20) and is white (-9). This wire was tested in TR-2199[1] and in TR-2145[2] and is identified by wire code #3.

3. MIL-W-81044/18-20-9. This is a single extruded alkane-imide with an imide topcoat. It has a tin coated 19 strand copper conductor (AWG 20) and is white (-9). This wire was tested in TR-2199[1] and TR-2145[2] and identified by wire code #4.

4. MIL-W-81381/11-20-N. This is a fluorocarbon/polyimide insulated wire with imide topcoat. It is the same as MIL-W-81381/7-20-2 wire except that the insulation is thicker. It is natural (-N) color. This wire was tested in TR-2199[1] and in TR-2145[2] and identified by wire code #11.

5. MIL-W-81281/7-20-2. This is a fluorocarbon/polyimide insulated wire with imide topcoat. It has a silver coated 19 strand copper conductor (AWG 20) and is red in color (-2). This wire was tested in TR-2145[2] and identified by wire code #12. It can be compared with wire code #10 in TR-2199[1] since it is identical except for color.

6. 55A0811-20-9. This is an irradiated modified ETFE fluorocarbon insulation on tin coated 19 strand copper conductor (AWG 20) and is white (-9). This wire was not previously tested and is being considered for inclusion into MIL-W-22759.

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